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"FLUCTUATIONS OF ATTENTION" AND THE REFRACTORY PERIOD

IN an interesting and suggestive article published some two years ago[1] Professor Wallin suggested that it seemed possible to connect the fluctuations of attention as observed in reversible perspective and in observations of minimal stimuli with the refractory period of the reflex as it has been developed by modern physiologists, particularly by Sherrington. The obvious difficulty in the way of relating the two phenomena lies in their difference in duration. The intermittences in attention usually mentioned, reported by Lehmann, Marbe, Urbantschisch, and others, come every three to ten seconds or more, while the refractory period lasts only from one tenth of a second to a second at the maximum. During some years past Mr. Billings and Mr. Work have been studying in my laboratory and under my direction another periodic fluctuation that corresponds more closely to the period of the refractory phase of the reflex and which has several characteristics that make plausible the assertion that it is the sensory correlate of the refractory period of the reflex.

The phenomenon first attracted my attention in connection with recording the ordinary so-called attention waves. I noticed that frequently I would be uncertain just at what time the gray ring on the Masson ring had disappeared. I would seem to be distracted at the moment that I desired to notice it most. I would see that it had vanished, but could not see it go. This suggested that the most careful observation was not continuous, and that there was another periodic alternation of attention that was shorter than the usual attention wave, and superimposed upon it. Acting upon this suggestion Mr. Work began to experiment with several persons to determine whether such an intermittence of sensation was common, what its length might be, and to determine how it might be influenced by different conditions. When he was compelled to discontinue his work, Mr. Billings took it up and extended it. He will soon publish his results in detail.

The method of attack was perfectly simple and direct. A dot was placed before the subject and he was asked to press upon a key during the period when he was occupied with the dot, to lift his finger when he was distracted by anything whatever. Each subject worked with was found to give evidence of the fluctuation, and for all the different sorts of material investigated. Dots, parts of pictures, tones, and pressures were used as stimuli and all were found to be intermittent. There was always some difficulty in keeping the records since the observer often forgot to notice that he was not conscious of the stimulus in his interest in the distracting stimulus or event. It is the one instance in my knowledge in which the observation of the conscious process really interferes with the conscious process, as the older theoretical objections to introspection assumed that it must. Here interest in the mental process interfered with recording the changes rather than *vice versa.* The observer would remember after attention had wandered to several other things that it had wandered and would then lift his finger. He would be conscious that several things had been attended to, but could record the whole series only as continued attention to the stimulus. This source of error in the measurements was always present and tends to make all values given for the time of attention to an object too large.

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[1] This JOURNAL, Vol. VII., page 33.

Another difficulty that was much in evidence early in the observations was that it was hard to distinguish between assurance that the dot had not vanished objectively and its continuous presence as a conscious process. One might be certain that the dot were still present all the time, but not have observed it continuously. In this respect these alternations are different from the ''attention wave'' in the classical use of the term. Those can frequently be seen to vanish or seen to reappear. These can only be recorded in retrospect as an awareness that one was not looking just before. As soon as the observer becomes conscious that he is not looking his attention is at once attracted to the object, and it again enters consciousness. It is hard for the inexperienced observer to believe that the object has not been in consciousness all the time, since he is certain that the stimulus has been acting continuously. It is this ''stimulus error'' undoubtedly that has prevented the phenomenon from being observed earlier. The practical certainty that an object persists obscures the intermittence of its image. Another difference between the older recognized ''attention waves'' and these is that in the former the fluctuations are confined to stimuli of liminal intensity while these affect all stimuli, whatever their intensity. This difference contributes in some degree to the difficulty mentioned above of discriminating between objective persistence and subjective intermittence.

The general results showed that all of the individuals could with a little practise observe the fluctuations and record them. Occasionally at first they would be sceptical about their existence or their ability to register them, but a few minutes' training would bring them out and a few hours would serve to give sufficient training to produce satisfactory records. The times varied somewhat for different subjects and for the same subjects, in the different series. The range for most was from 0.2 second to 6 seconds. The average for the different subjects ranged from about 1.0 second or a little under to 2 seconds. The average is probably too high for two reasons. The first is due to the frequency with which disappearances are overlooked through interest in the distracting stimulus or process. Even in the most successful series these were large in number. The second depends upon the fact that each fluctuation recorded really involves two acts, one the turning to the distraction, the other the recognition that distraction had taken place. To obtain the length of each single mental wave it would be necessary to divide by two for this correction, and that would still leave the averages too large for the length of the longest period that one can attend. If we compare these reduced values we would find that the periods of attention would be of approximately the same length as the reflex and its refractory period, from .1 to 1.0 second as noted in the beginning of the article. It should be added that this time could not be changed by voluntary effort. The wave was of the same length when a strong effort was made to hold the attention to the one object as when consciousness was permitted to follow its natural course. One of the few factors that showed any effect upon the length of attention was increasing the size or complexity of the object attended to. This seemed to lengthen the period, as might be expected, since the large object would permit many different phases or parts to come under observation successively. This was not to be ascribed to the lengthening of the separate impulses, but merely to the fact that the changes do not necessarily bring new objects into consciousness. As the experiments involved in all some twenty thousand observations, it would seem that considerable weight must be given to the conclusion.

We may conjecture from these observations that just as motor discharges are strictly limited in the rate at which they may repeat themselves by the fact that the discharge of the nervous impulse is intermittent or rhythmical and that each discharge is followed by a period of incapacity, the appreciation of objects through the senses is similarly intermittent, that consciousness is made up of pulses that can not last more than a second or so. The apparent continuity of a conscious state is due to the rapidity with which these pulses succeed each other and to the fact that it is assumed that objects are present persistently between the pulses. This is probably also due in part to the fact that objective change will invariably attract attention to the object from the distracting stimulus. When attention has not thus been forcibly attracted it is assumed that the object has been persistently present, and this is mistaken for continuous observation. These pulses come every 0.2 second or so, are fairly constant for all conditions, can not be influenced by voluntary effort or desire and affect all external impressions. It follows, if these results be accepted, that all consciousness or at least all observation of external events is intermittent. What is in effect continuous observation is made up of a number of rapidly following views that are interpreted to be persistent and uninterrupted. As one can hold the hand fairly steady in spite of the fact that the impulses that keep the muscles contracted are intermittent, so the perception of an object, or of a small part of the object, seems continuous in spite of the fact that the observation of no single phase of it can last more than a fraction of a second.

A study of the order and duration of the distracting stimuli indicates that this constant coming and going of consciousness holds for ideas as well as for sensations. In several series of experiments, the observer was asked to press a key whenever the distracting stimulus altered as well as when the object observed disappeared, and then was asked to make a list of the distracting events in order. This showed that memories were quite as often the distracting event as external things. It was found, as would be expected from older work on association, that these succeeded each other at about the same rate as the external sensations and had on the whole about the same laws and conditions. The general statement may be extended then to say that the entire stream of consciousness is made up of a number of small jets that change their character from once to several times a second. That these jets may be of external or subjective origin, and whatever their origin they are pieced together to constitute the series of experiences. The continuity of the stream comes from the use that is made of it rather than from its essential character, if these may be distinguished. The times of association, like the time of perception or the minimum of attention, might then be related to the time of discharge and recovery of the cortical cells.

It might be noted also that this time is within the range of several of the times that have a psychological importance and which at different times and by several authors have been referred to the older longer ''attention waves'' in spite of the fact that there was a marked difference in the length of the two times or processes. Thus the indifference time for estimations of time intervals is given between 0.5 and 0.75 second, which is about the time that it would be possible to keep a single tone in consciousness without change. The displacement of one of two stimuli by attention in the complication experiment may be nearly as large as half of our shortest period. Wundt early offered the periodic character of consciousness as an explanation for this. But the then known fluctuations were altogether too long. Our periods are still pretty long, but if it is assumed that the displacement represents the time between the peaks of two alternating series of impressions, they might be brought into somewhat close connection. Just beyond the outer limit of our range stands the most satisfactory period of preparation for a reaction. If a signal is given from one to two seconds before the stimulus it is found that the reaction is shortest. This again may be related to the time that must elapse between one apex of attention and the next. One might also suggest that the specious present was limited by the time that a simple sensation could receive attention or persist in consciousness. This seems, however, to be limited, by the memory after-image, which in turn evidently lasts through a number of these shortest alternations, rather than by the single pulse of response. It should of course be said that it is hardly probable that all of the other times should prove to be ultimately connected with this period of maximum duration of a simple conscious experience, but it is at least significant that the time required for association, the indifference point for the comparison of intervals, the most favorable time of preparation for a reaction, should lie within the limits that our observers gave as the minimum time between successive appreciations of a simple object, and this also corresponds fairly closely to refractory period of the reflex. How they may all be related is not always clear, but each has been regarded as connected with the old "attention wave" by one or more authorities, in spite of the difference between these absolute durations. We may leave the more detailed discussion of this point to others. Our purpose is fulfilled when it is seen that the length of attention waves as observed corresponds with the times of other processes that have been or may be connected with them.

A secondary question arises as to the relation of these fluctuations to the longer and earlier described "attention waves." It seems probable that the two are of altogether different nature and origin. The times do not at all overlap. They differ, too, in that in these short pulses the object is always appreciated as in consciousness if one definitely looks for it, while the minimal stimulus that fluctuates in the longer waves is out of consciousness and can not be brought back by attending. Again these short alternations affect stimuli of all intensities, are not confined, as are the others, to faint stimuli. That they are different seems clear from the fact that the shorter may be a hindrance to the appreciation of the longer waves. These three considerations suffice to mark the two sets of fluctuations as of fundamentally different character and probably of different origin. The longer waves may be related to the long circulatory waves as I and several of the workers in my laboratory among others found evidence for, or they may be related to fatigue processes in the sense organ as Ferree thought. These new shorter ones are more directly connected with the ultimate perceiving process and from their times as indicated above seem related to the latent period and period of recovery of the sensory neurones concerned in consciousness.

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